DACA42-03-C-0024

Midterm Report
CERL HQ Site Demonstration Project
Champaign, IL

Proton Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY03

Headquarters:

1080 Holcomb Bridge Rd
Suite 100-175
Roswell, GA 30076
Ph (770) 650-6388

ERDC/CERL Site
Equipment Shed Building
Champaign, Illinois
September 25, 2006

California:

74837 Diamond Bar Rd
29 Palms, CA 92277
Ph (760) 367-5005

Executive Summary

Under terms of its FY'02 DOD PEM Demonstration Contract with ERDC/CERL, LOGANEnergy installed and is operating a Plug Power GenSys 5kWe Combined Heat and Power (CHP) fuel cell power plant at ERDC/CERL, Champaign, Illinois. The site selected for the one-year demonstration project is adjacent to what is locally known as the Pole Barn (actually an equipment shed).

The unit is electrically configured to provide grid parallel/grid independent service to the site, as well as be thermally integrated with a fan coil space heater to provide supplemental heating to the equipment shed during the test period. The methodologies to accomplish these tasks are found in the paragraphs that follow. Local electrical and mechanical contractors were hired to provide services as needed to support the installation tasks. It is anticipated that the project will add $4,390 of annual energy costs to CERL during the period of performance. The POC for this project is Nick Josefik whose coordinates are: nicholas.m.josefik@erdc.usace.army.mil and 217.373.4436.

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Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

LOGANEnergy Corp. Small Scale PEM 2004 Demonstration Project at the U.S. Army Engineer Research and Development Center (ERDC), Construction Engineering Research laboratory (CERL), Champaign, IL

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation
1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 Phosphoric Acid Fuel Cells (PAFC) and PEM fuel cell projects at 21 locations in 12 states, and has agreements to install 22 new projects in the US and the UK over the next 18 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P Liquid Propane (LP) Gas unit, and the GenCore 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug Power will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Scott Wilshire is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1338, and his email address is scott_wilshire@plugpower.com.

4.0 Principal Investigator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability. LOGAN performs the quarterly and annual service prescribed by the UTC, and performs other maintenance as required. The periods of unavailability are chiefly due to persistent inverter problems that seem to be endemic to the Toshiba power conditioning balance of the system. Field modifications and operating adjustments have largely cured the problem. Quarterly service events take 10 hours to complete with the unit under load, and the annual event takes approximately 35 hours with the unit shut down.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Mr. Scott Wilshire.
968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ex 1338

LOGAN performed the start-up of both units after Southern Maryland Electric Cooperative completed most of the installation work. The units are located at residential sites at Patuxant

River Naval Air Station, MD and operate in standard gird connected/grid independent configurations. Both operate at 4.5kWe and have maintained 98% availability. The units, S/Ns 241 and 242 are two of the very latest GenSys models to reach the field. S/N 242 is Plug Power's first LPG fueled system to go into the field. Both have set new performance standards, and raised expectations for near term commercial viability for this product. Operations to date are indicative of the success of the various test and evaluation programs that have been conducted over the past two years.

c) Contract: A Partners LLC; Commercial PC25 Fuel Cell Project Design, Installation and 5-year service and maintenance agreement.

Mr. Ron Allison
A Partners LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

On April 20, 2004 LOGAN completed the installation of a 600kWe PC25C Combined Heat and Power (CHP) fuel cell installation in Fresno, CA. The system operating configurations allow for both grid parallel and grid independent energy service. The grid independent system is integrated with a Multi Unit Load Sharing (MULS) electronics package and static switch, which initial development was funded by ERDC CERL in 1999. This is the third fuel cell installation that uses the MULS System. The thermal recovery package installed in the project includes a 100-ton chiller that captures 210 degree F thermal energy supplied by the three fuel cells to support cooling loads on the first three floors of the host facility. The fuel cells also provide low-grade waste heat at 140 degrees F that furnishes thermal energy to 98 water source heat pumps located throughout the 12-story building during the winter months.

7.0 Host Facility Information

Figure 1 - CERL Main Entrance

The Construction Engineering Research Laboratory is located in Champaign, Illinois. The Construction Engineering Research Laboratory (CERL) is part of the U.S. Army Engineer Research and Development Center (USAERDC), which is the Army Corp of Engineers' integrated research and development (R&D) organization. CERL conducts research to support sustainable military installations. Research is directed toward increasing the Army's ability to more efficiently construct, operate, and maintain its installations and ensure environmental quality and safety at a reduced life-cycle cost. Excellent facilities support the Army's training, readiness, mobilization, and sustainability missions. An adequate infrastructure and realistic training lands are critical assets to installations, which serve as platforms to project power worldwide. CERL also supports ERDC's R&D mission in civil works and military engineering.

Figure 2 - CERL Facilities Aerial View

CERL works closely with its Army customers to develop quality products and services and to help customers implement new technologies. User groups and steering committees have been established to help identify existing problems, establish research priorities, and provide input into the development of products. Many CERL products developed under this teamwork approach are in daily use, both within the Department of Defense and the private/public sectors. An active technology transfer program ensures these products receive the widest dissemination among prospective users.[i]

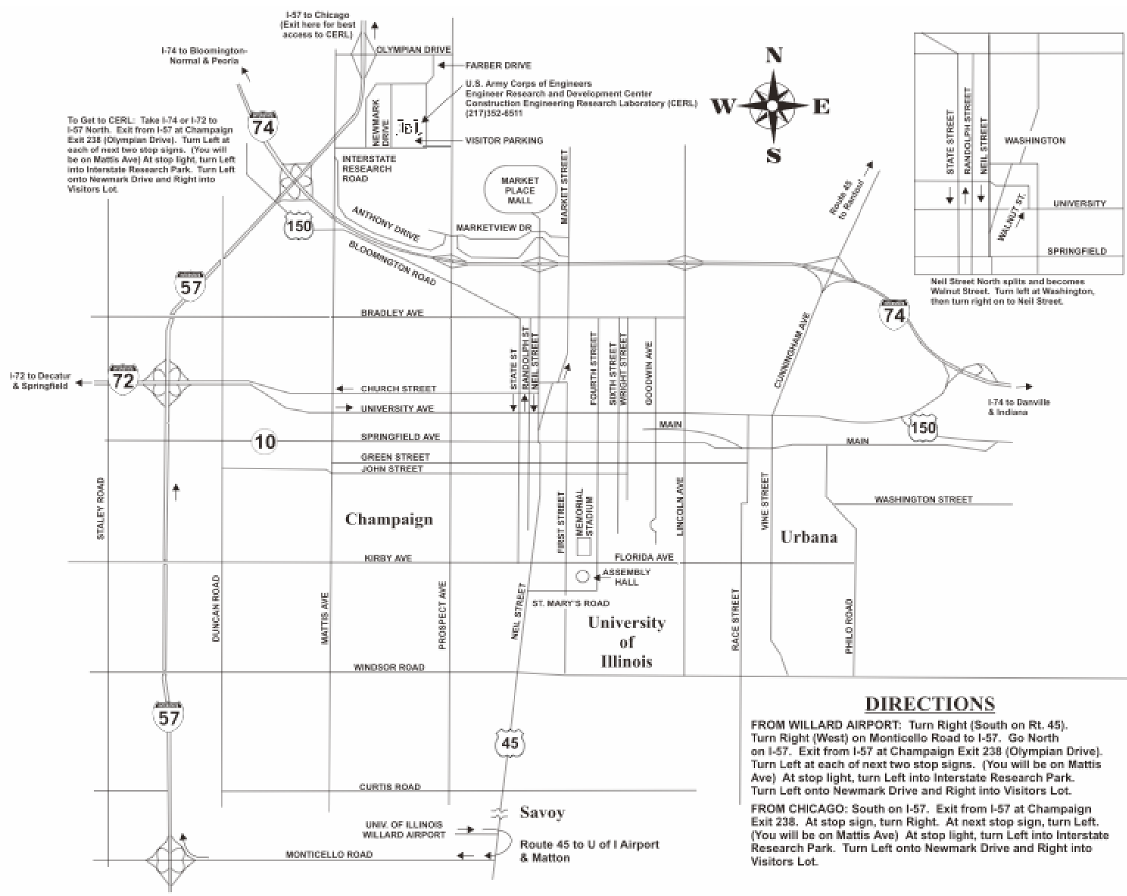

Figure 3 - Map to CERL Facilities

8.0 Fuel Cell Installation

In January 2006, completion of the fuel cell installation and interconnect agreements with the utility company permitted the commencement of the one year demonstration. The fuel cell is located west of the “Pole Barn” as shown in Figure 4. The “Pole Barn” (equipment shed) is used by maintenance personnel to store various trucks and other motive equipment. This building also houses a small workshop with work benches and various machine tools. The fuel cell was installed on concrete pads located west of the Pole Barn and an adjacent access road. The fuel cell was set back approximately 8 feet from the access road. The access road is frequently used in the winter by snow removal equipment as well as by other equipment during the remainder of the year. The 8 foot set off was chosen to assure complete access by all vehicles and no protective bollards were required at the fuel cell site. All fuel cell connections were made. The interfaces include phone, internet, a make-up water line, thermal recovery, and electric power lines. The fuel cell chosen for this demonstration project is operating on liquid propane gas (LPG). The LPG tank is located near the fuel cell as can be seen in Figures 4 and 5.

Figure 4 - Fuel Cell Site

Figure 5 - Installed Fuel Cell

9.0 Electrical System

The Plug Power GenSys5C PEM fuel cell power plant provides both grid parallel and grid independent operating configurations for site power management. This capability is an important milestone in the development of the Gensys5 system on the pathway to product commercialization. The unit has a power output of 110/120 VAC at 60 Hz, and when necessary the voltage can be adjusted to 208 VAC or 220 VAC, depending upon actual site conditions and requirements. The fuel cell has been connected in parallel with the CERL electrical service via a new circuit breaker panel that LOGAN has installed in the equipment shed building at the existing service panel. In addition, a separate grid-independent emergency panel has been installed to provide service to dedicated loads in the event of a failure of the utility grid feed to the site. The dedicated loads are the overhead lights in the equipment shed high bay area. This emergency panel can be seen pictured in Figure 6. Additionally, an emergency disconnect switch and electric meter have been attached to a mounting bracket on one side of the fuel cell. The mounting bracket designed and used by LOGAN technicians on the GenSys model has allowed for easy access to important electrical junctions close to the fuel cell. The mounting bracket and accompanying electrical hardware can be seen in Figure 7.

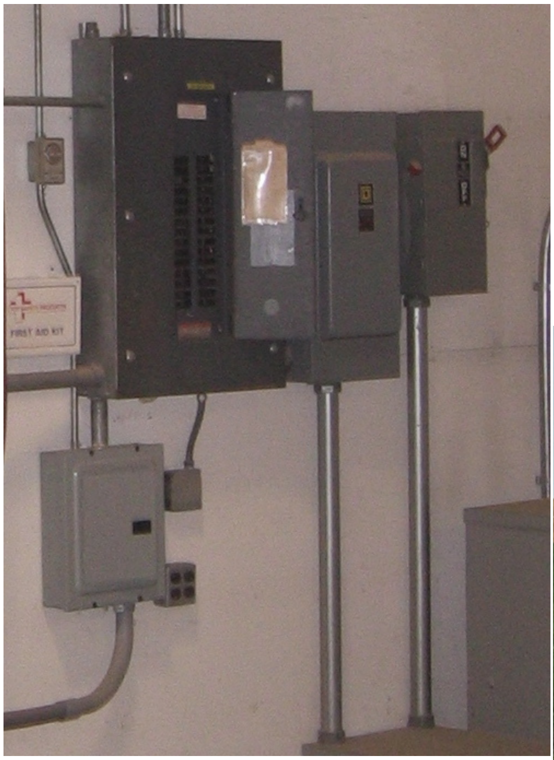

Figure 7 – Grid Independent Panel

Figure 6 – Mounting Bracket and Components

10.0 Thermal Recovery System

Figure 8

New Fan Coil Unit and Existing Electric Unit

In order to demonstrate this capability, LOGAN installed a fan coil unit in the equipment shed. A picture of the fan coil unit can be seen in Figure 8. The unit is suspended from the equipment shed's wall next to the existing electric space heater (also seen in the photo). The unit was plumbed into the fuel cell's heat exchanger that supplies 7,800 Btu/h at 60 degrees C with a flow rate of 2.5gpm. The new unit's fan is controlled thermostatically. By setting the thermostat of the new fan coil a degree or two lower than the electric heater, the fuel cell heat will be used first and the electric heater will supplement as needed.

11.0 Data Acquisition System

LOGAN has installed a Connected Energy Corporation (CEC) web-based Supervisory Control And Data Acquisition (SCADA) system that provides high-speed access to real-time monitoring of the power plant. The schematic drawing seen in Figure 9 describes the architecture of the CEC hardware that will support the project. The system provides a comprehensive data acquisition solution and also incorporates remote control, alarming, notification, and reporting functions. The system picks up and displays a number of fuel cell operating parameters on functional display screens, including kWH, cell stack voltage, and water management, as well as external instrumentation inputs including Btus, fuel flow, and thermal loop temperatures. CEC's Operations Control Center, located in Rochester, New York, maintains connectivity by means of a Virtual Private Network that links the fuel cell to the center.

To view the operation of this unit, log on to https://www.enerview.com/EnerView/login.asp Then login as: logan.user and enter the password: guest. Select the box labeled CERL, or navigate other LOGAN sites using the tool bars or html keys.

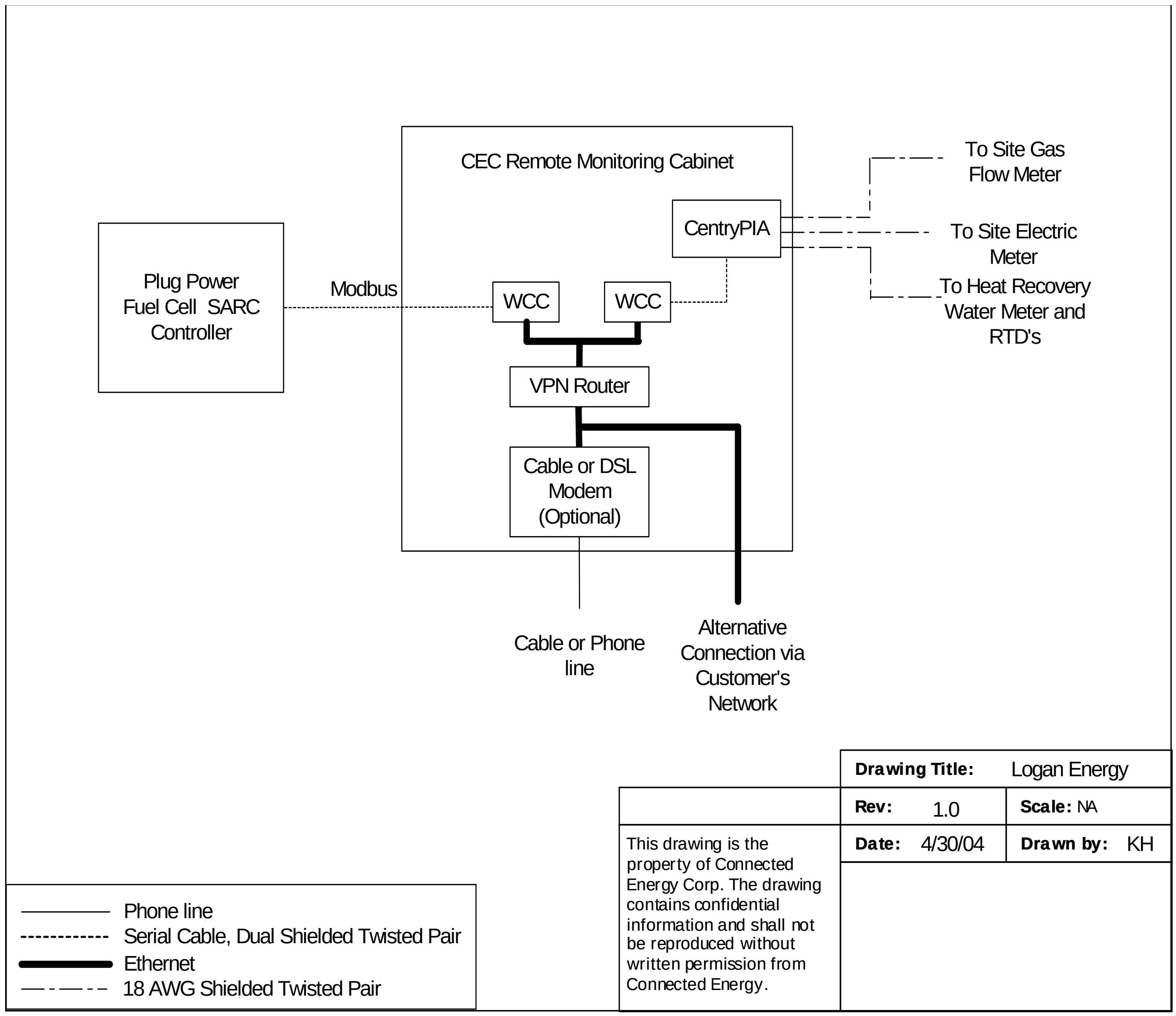

Figure 9 - CEC WEB Enabled SCADA Terminal Hardware

LOGAN has obtained high-speed internet connection to the fuel cell router from the local CERL network. The CERL network site contractor was helpful in providing a network connection in the equipment shed building.

12.0 Fuel Supply System

This GenSys unit operates on propane. A local vendor provided a 500 gallon propane tank and makes periodic refueling visits. The tank is located near the fuel cell (see Figures 4 and 5) and the short piping run is underground from the tank to fuel cell. The propane meter is located at the tank.

13.0 Installation Costs

March Air Reserve Base Building 400						
Project Utility Rates			**Utility**			
1) Water (per 1,000 gallons)	$12.13		City of Atlanta			
2) Utility (per KWH)	$0.0500		Georgia Power			
3) Natural Gas (per MCF)	$6.63		Georgia Gas Co.			
First Cost					**Estimated**	**Actual**
Plug Power 5 kW GenSys5C					$ 65,000.00	$ 65,000.00
Shipping					$ 1,800.00	$ 1,060.00
Installation electrical					$ 1,250.00	$ 924.00
Installation mechanical & thermal					$ 3,200.00	$ 1,700.00
Watt Meter, Instrumentation, Web Package					$ 3,150.00	$ 2,950.00
Site Prep, labor materials					$ 925.00	$ 1,125.00
Technical Supervision/Start-up					$ 8,500.00	$ 13,860.00
Total					**$ 83,825.00**	**$ 86,619.00**
Assume Five Year Simple Payback					$ 16,765.00	$ 17,323.80
Forcast Operating Expenses	Volume		$/Hr		$/ Yr	
Natural Gas MCF/ hr @ 2.5kW	0.03	$	0.22		$ 1,716.47	
Water Gallons per Year	14,016				$ 170.01	
Total Annual Operating Cost						$ 1,886.49
Economic Summary						
Forcast Annual kWH			19710			
Annual Cost of Operating Power Plant		$	0.096	kWH		
Credit Thermal Recovery Rate			($0.010)	kWH		
Project Net Operating Cost		$	0.085	kWH		
Displaced Utility cost		$	0.050	kWH		
Energy Savings (Cost)			($0.035)	kWH		
Annual Energy Savings (Cost)			($698.34)			

Explanation of Calculations:

Actual First Cost Total is a *sum* of all the listed first cost components.
Assumed Five Year Simple Payback is the Estimated First Cost Total *divided by* 5 years.

Forecast Operating Expenses:
Propane usage in a fuel cell system set at 2.5 kW will consume 0.53 gallons per hour. The cost per hour is 0.53 gallons per hour *x* the cost of propane to the site per gallon at $1.50. The cost per year at $6267.78 is the cost per hour at $0.80 *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.
The fuel cell systems set at 2.5 kW will consume 1.6 gallons of water per hour through the Deionized Water (DI) panel. The total volume of water consumed at 14,016 gallons per year is 1.6 gph *x* 8760 hours per year. The cost per year at $23.41 is 14,016 gph *x* cost of water to the site at $1.67 per 1000 gallons.
The Total Annual Operating Cost, $1886.49 is the *sum of* the cost per year for the natural gas and the cost per year for the water consumption.

Economic Summary:
The Forecast Annual kWh at 19,710 kWh is the product of the 2.5 kW set-point for the fuel cell system *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.
The Annual Cost of Operating the Power Plant at $0.096 per kWH is the Total Annual Operating Cost at $1886.49 *divided by* the forecast annual kWh at 19,710 kWh.
The Credit Annual Thermal Recovery at -$0.010 is 7800 *divided by* 3414. This is then *multiplied by* 0.9 *x* 0.1*x* the cost of electricity at $0.0500 per kWh *x* (-1). As a credit to the cost summary, the value is expressed as a negative number.
The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Credit Annual Thermal Recovery.
The Displaced Utility Cost is the cost of electricity to CERL per kWh.

Energy Savings (cost) equals the Displaced Utility Cost *minus* the Project Net Operating Cost.
Annual Energy Savings (cost) equals the Energy Savings *x* the Forecast Annual kWh.

14.0 Acceptance Test

The CERL Headquarters fuel cell system number SU01B000000313 was officially commissioned by LOGAN technicians on January 28, 2006 after passing its 8-hour acceptance test earlier that day. Kilowatt output during the commissioning test on January 28th is shown on the graph below taken directly from the Connected Energy monitoring system database.

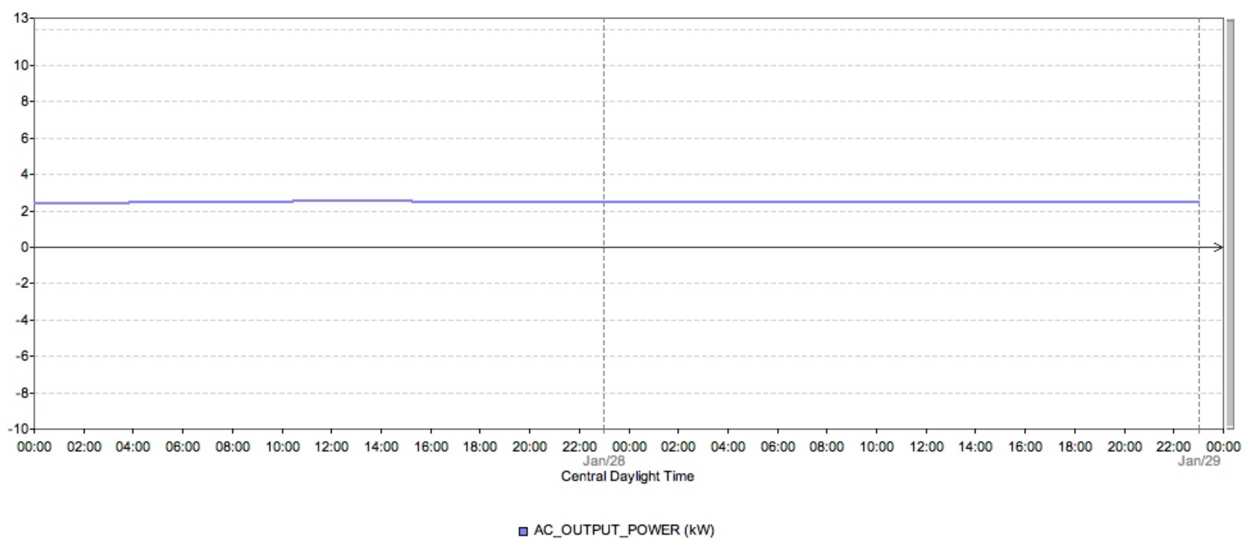

Figure 10 - Commissioning Test 28 Jan 2006 - kW Output

Appendix

1) Monthly Performance Data

January Summary
The CERL Headquarters fuel cell system number SU01B000000313 was officially commissioned by LOGAN technicians on January 28, 2006 after passing its 8-hour acceptance test earlier that day. The fuel cell currently has a project availability of 100% after running uninterrupted for the remainder of the month. The system includes a heat recovery system that provides space heat into the “Pole Barn” and is monitored through the Connected Energy real-time monitoring interface. The Connected Energy package was successfully installed upon commissioning and currently monitors the fuel cell activity of system number SU01B000000313. The fuel cell ran at 100% availability during the month after the commissioning on January 28, 2006.
Shutdown Date(s): None
Replaced Component: None

February Summary
The fuel cell shut down on February 17 after experiencing a component failure which compromised the operation of its radiator fan. A LOGAN technician was available to make a site visit on February 22, at which point the problem was resolved. The issue was corrected by checking the system wiring and testing the radiator fan upon startup to ensure it was functioning properly. The system was then restarted and ran without complications for the remainder of February. The fuel cell ran at 82% availability during the month of February, with only the one shutdown involving a component failure.
Shutdown Date(s): Feb 17-22, 2006
Shutdown Duration: Approximately 123 hours
Replaced Component: None

March Summary
The fuel cell shut down on March 21 after experiencing what was thought to be a pump failure. A LOGAN technician was available to make a site visit later that week, at which point it was determined that instead it was a failure with the motor control board (MCB). The issue was corrected by replacing the control board, but then issues involving the inverter and Stack and Reformer Control (SARC) board arose upon attempting a restart. The technician on-site then had to wait for replacement parts to arrive and the service was completed at the end of March. The CERL Headquarters fuel cell ran at 64% availability during the month of March. The thermal system successfully utilized more than 6 million Btus of waste heat during March.
Shutdown Date(s): March 21 - 31, 2006
Shutdown Duration: Approximately 269 hours
Replaced Components: Motor Control Board, SARC Board, Power Inverter

April Summary
The fuel cell ran at 100% availability during the month of April while recovering more than 10 million Btus in fuel cell waste heat.
Shutdown Date(s): none.
Replaced Components: none.

May Summary
The unit shut down late on May 3rd, and LOGAN worked hard the rest of the month to troubleshoot and address the various technical problems (see the May monthly report for details). Over the course of the month, several components were replaced, including the stack. By June 1st, the system was up and running again. The fuel cell ran at 13% for the month of May.

Shutdown Date(s): May 3 - 31, 2006
Shutdown Duration: Approximately 672 hours
Replaced Components: Scanner cards, SARC, LPG sensor, Stepper motor control board, and air TSI & snorkel filter.

June Summary
The fuel cell ran at 100% availability for the month of June.
Shutdown Date(s): none.
Replaced Components: none.

Fuel Cell Site Totals Thru June 2006

Run Time (Hours)	2632
Time in Period (Hours)	3696
Availability (%)	71.21%
Energy Produced (kWe-hrs AC)	6700.3
Output Setting (kW)	2.50
Average Output (kW)	2.55
Capacity Factor (%)	36.26%
Fuel Usage, HHV (BTUs)	8.86E+07
Fuel Usage (SCF)	87542
Electrical Efficiency (%)	25.83%
Thermal Heat Recovery (BTUs)	28305192
Heat Recovery Rate (BTUs/hour)	10754.25
Thermal Efficiency (%)	31.96%
Overall Efficiency (%)	57.80%
Number of Scheduled Outages	0
Scheduled Outage Hours	0
Number of Unscheduled Outages	3
Unscheduled Outage Hours	1064

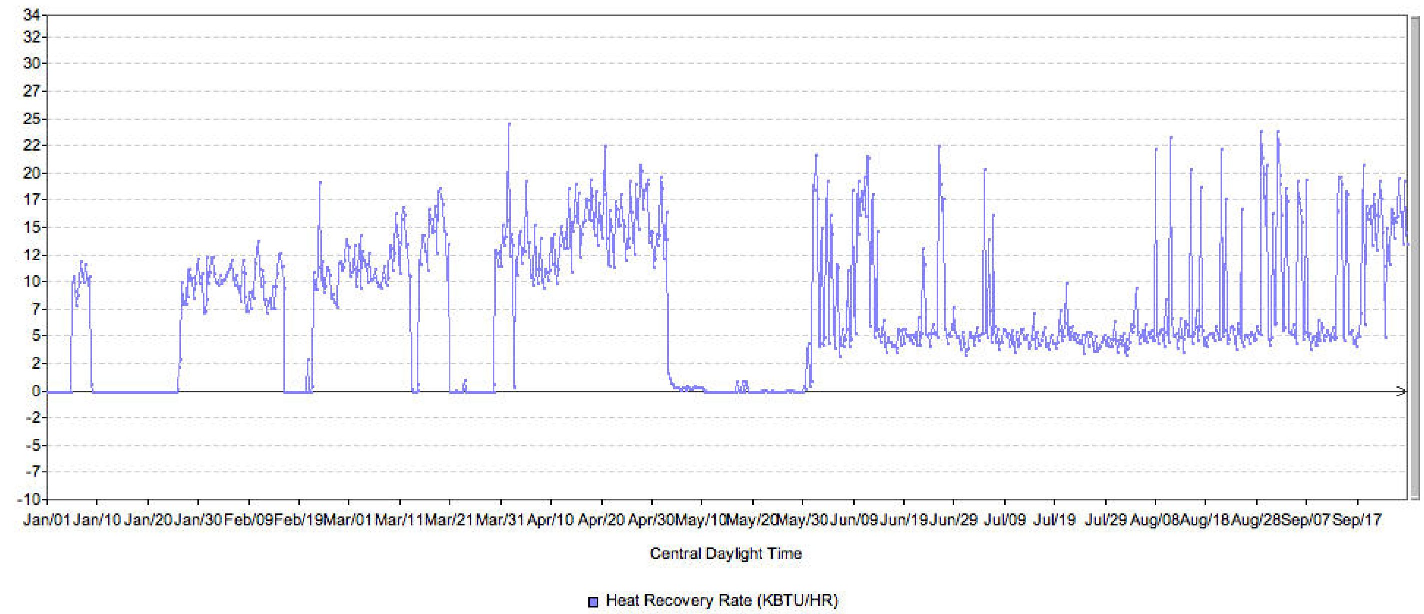

Figure 11 - Heat Recovery Rate at CERL HQ in kBtu/hr. for Jan-Aug '06

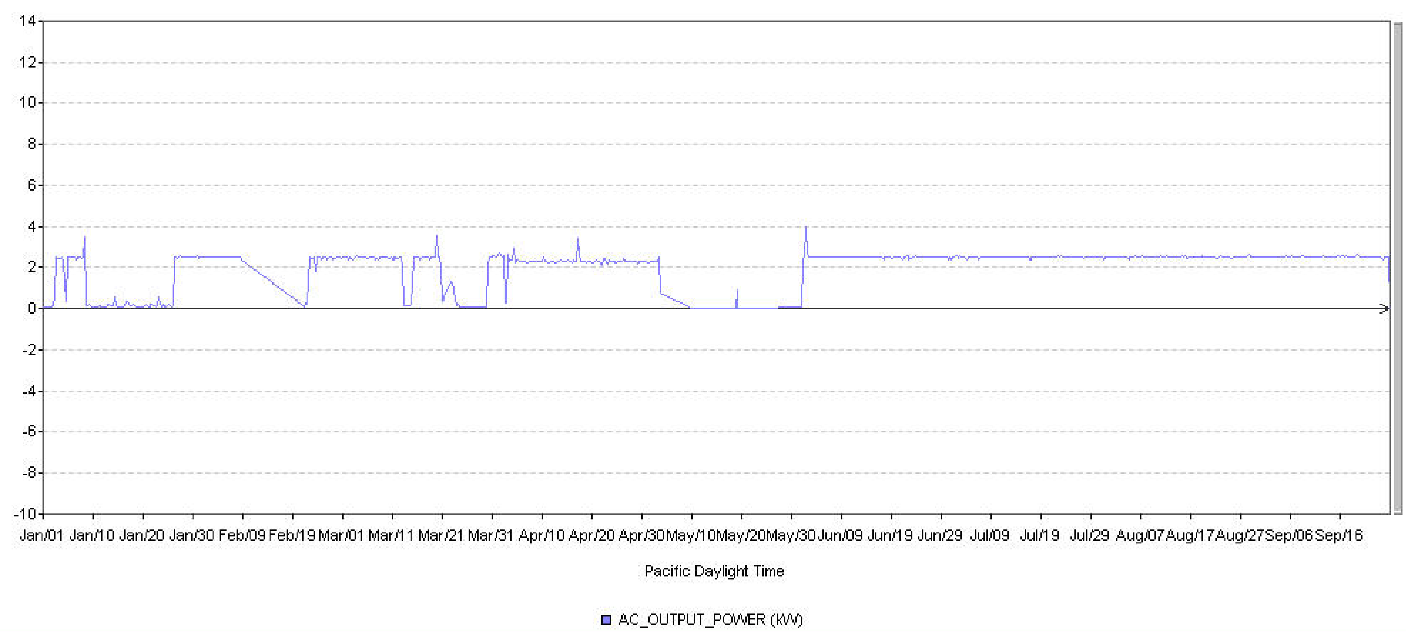

Figure 12 - A/C Output Power at CERL HQ in kW for Jan-Aug '06

CERL - Champaign Monthly Report						
Time Frame	Total Energy Produced (kWh)	Average Energy Rate (kW)	LVH Electrical Efficiency (%)	Total Heat Recovery (kBTU)	LHV Combined Efficiency (%)	Gas Consumed (CCF)
January 2006	674.4	0.9	27.3	2,050.1	51.6	3,636.0
February 2006	1,339.4	2.0	25.3	5,530.0	56.0	7,772.0
March 2006	1,209.7	1.7	24.3	6,239.2	61.0	7,315.0
April 2006	1,614.8	2.3	22.9	10,184.3	65.2	10,366.0
May 2006	11.6	0.2	0.0	1,278.5	0.0	119.0
June 2006	1,657.5	2.5	23.6	5,900.9	48.2	10,322.0
July 2006	1,833.1	2.5	24.2	4,035.3	39.8	11,133.0
August 2006	1,842.5	2.5	23.6	5,016.6	42.4	11,475.0
September 2006	658.5	2.5	23.1	7,214.3	97.4	4,183.0
Report Average:	1,204.6	1.9		5,272.2		7,369.0

Report start date: 01/01/2006

Report end date: 09/26/2006

Figure 13 - Monthly Summary (from CEC Web Site)

[i] Mission Statement from CERL Web Site - http://www.cecer.army.mil/td/tips/product/details.cfm?ID=458